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156W TRANSCEIVER MULTICOUPLERS.(U)
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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
CORADCOM - 77-0193-5

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156W TRANSCEIVER MULTICOUPLERS

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Rockwell International
Collins ~~Government~~ Telecommunications Products Division
Cedar Rapids, Iowa 52404

SC 392655

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report describes the activity during the first annual report period of Contract DAAB07-77-C-0193. The frequency ranges of a 2-channel and a 5-channel vhf multicoupler developed under a previous contract are extended. In addition, a "dummy" filter designed to replace an unused channel is described. Design parameters and test data are presented.

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156W TRANSCEIVER MULTICOUPLERS

Prepared for CENCOMS, US Army CORADCOM

1. INTRODUCTION

This annual report summarizes the activity on the 156W Transceiver Multicoupler under contract DAAB07-77-C-0193.

During the previous Phase II contract, DAAB07-75-C-0113, a 2-channel multicoupler and a 5-channel multicoupler were developed which operated over the frequency range of 30 to 80 MHz. These multicouplers performed well and met all requirements. The current Phase III program requires the upper frequency range of the multicouplers to be expanded to 88 MHz. In addition to the expanded frequency range, a "dummy" filter module is to be developed. This "dummy" filter may be substituted for any filter module to replace any unused channels. Also required is the development of drawings suitable for production.

These tasks have been completed during this report period. Figures 1-1 and 1-2 are the engineering model multicouplers. Figure 1-2 is the 5-channel multicoupler with two "dummy" filter modules installed. Preliminary evaluations indicate all contractual requirements are satisfied.

Qualification testing and the production build of ten 2-channel and ten 5-channel multicouplers will be completed during the final report period.

Figure 1-1. 2-Channel Multicoupler.

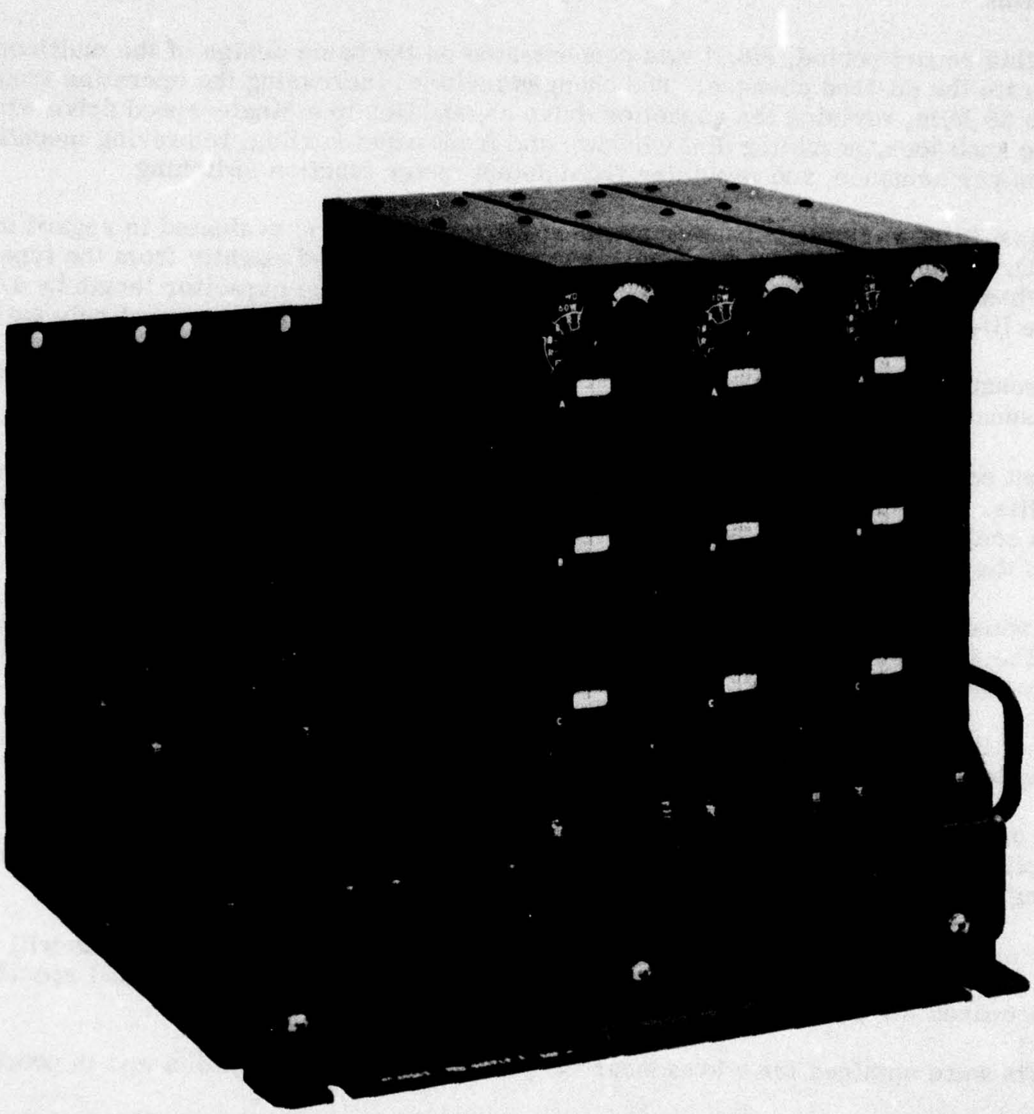


Figure 1-2. 5-Channel Multicoupler With "Dummy" Filters.

2. DEVELOPMENT STATUS

The modification of the basic multicoupler design to incorporate the required changes is divided into four chronological report periods.

2.1 First-Quarter Report Period

2.1.1 Status

During this report period, effort was concentrated on the basic design of the multicouplers to incorporate the desired changes. The changes included increasing the operating frequency range to 88 MHz, revising the capacitor drive assemblies to a single-speed drive with a separate knob lock, providing dial windows and front panel sealing, improving mounting and vibration performance, and providing fixed detent meter function switching.

Three gas-filled variable capacitor samples were obtained and evaluated in regard to capacity range, Q, and mechanical configuration. The samples differed slightly from the type employed in the Phase II configuration. The manufacturer increased the capacitor length by 1/8 inch to improve life. Evaluation of the longer capacitors showed that they were entirely satisfactory.

The resonator helix was resized to allow tuning to 88 MHz. To accomplish this result, the self-resonant frequency of the helix was increased from 99 to 109 MHz.

The input coupling to the 3-pole filter was revised to give the desired degree of coupling up to 88 MHz. The same approach was employed as used in the Phase II equipment (tapped helix in conjunction with a fixed series inductance). Both location of the tap point and the value of the series inductor were changed slightly to provide the desired coupling.

The forward/reflected power discriminator was checked to 88 MHz and found to be satisfactory. The PC board conformed to MIL requirements but required a small modification to accommodate standard parts.

Design of the coupling apertures was completed. These now provide the desired degree of coupling to 88 MHz.

Design of the output coupling to extend the filter's frequency range to 88 MHz was accomplished. The previously used technique was retained. Tap location and transmission line length were changed slightly to achieve proper operation.

Review and selection of military standard parts was completed. All QPL parts will be used except for the variable tuning capacitor (no standard part available). Internal specifications were prepared for parts not presently in the Collins system.

All parts were obtained for a breadboard 3-pole filter, and construction was in process.

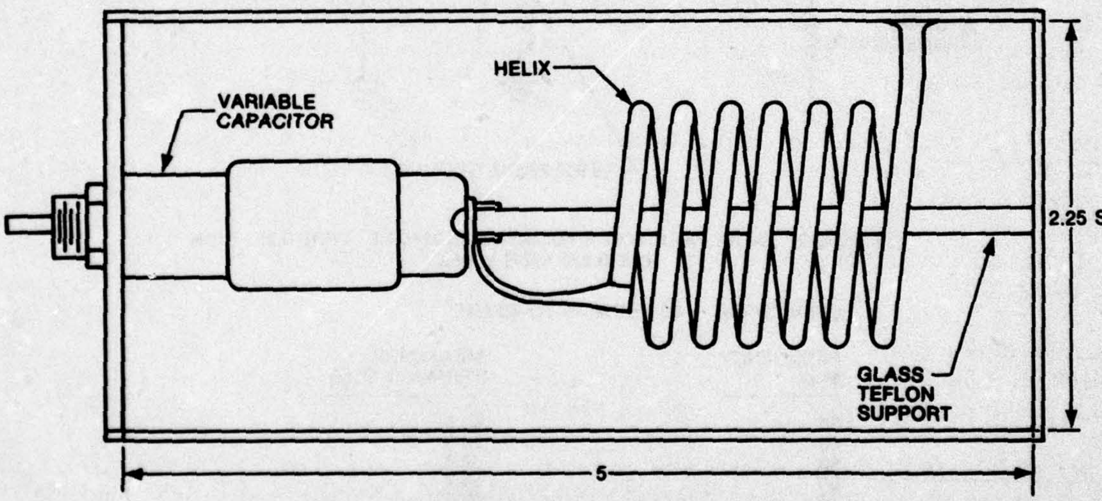
Parts for a trial capacitor drive assembly and knob lock were ordered; 75 percent of the parts were received.

Theoretical design of the lumped-element (7- to 50-ohm) transformer for increased bandwidth was completed. A breadboard unit was constructed and evaluated, with good results.

2.1.2 Results

The results obtained during the first quarter are detailed in the following figures. Figure 2-1 shows the configuration of the basic resonator to be employed in the filter. The construction is similar to that used in the phase II equipment. To preserve the overall filter volume, cavity size remains the same. The number of turns comprising the helix was reduced to allow operation to 88 MHz. The measured unloaded Q is comparable to that obtained in the prior equipment, ensuring that the insertion loss specification will be met.

Details of the input coupling to the filter are shown in figure 2-2. Again the design approach is identical to the Phase II equipment. Tap location and series inductance were adjusted to



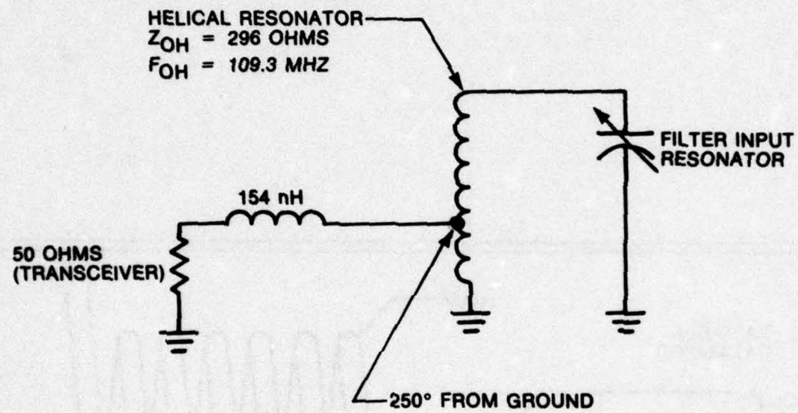
HELIX DETAILS: 6-1/3 TURNS, 1/8-INCH DIAMETER WIRE, SPACED 1/4-INCH, NOMINAL DIAMETER 1.312 INCHES. Z_{OH} = 296 OHMS, F_{OH} = 109.3 MHZ

FREQUENCY MHZ	MEASURED UNLOADED Q, Qu
30	610
40	688
50	749
60	787
70	821
80	847
88	850

Figure 2-1. Resonator Dimensions and Measured Unloaded Q.

provide good operation up to 88 MHz. Input terminal Q agrees closely with the desired value, as shown.

Redesign of the apertures for increased frequency range was accomplished by moving the existing aperture closer to the rear of the resonator as shown in figure 2-3. This centers the aperture with respect to the adjacent helices. By removing turns, the center of the helical resonator coil was lowered. The measured magnitude of coupling is in good agreement with the desired value.



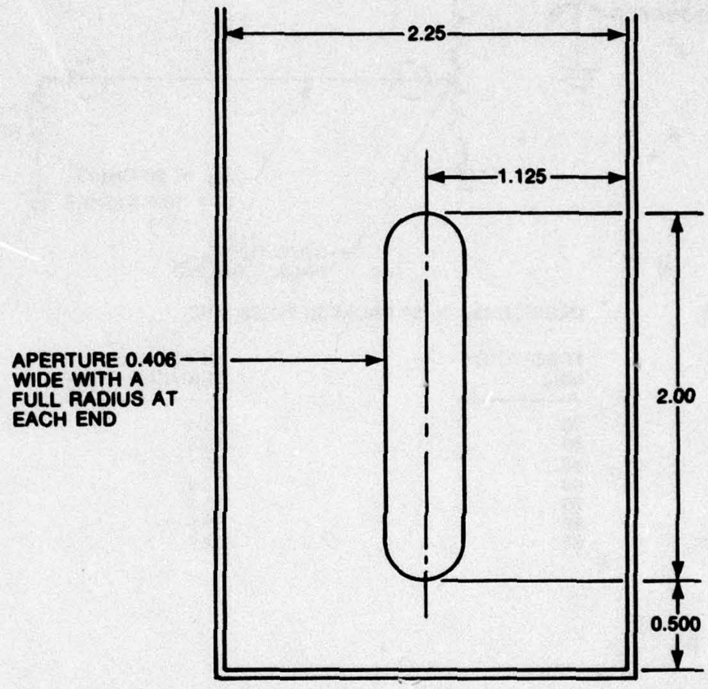
DETAILS OF 154 nH INDUCTOR: 6 TURNS NO 18 MAGNET WIRE 0.250 INCH ID X 0.323 INCH LONG

DESIRED Q_T = 59 FROM 30 TO 88 MHZ

FREQUENCY MHZ	MEASURED TERMINAL Q, Q_T
30	62.8
40	58.3
50	57.0
60	56.7
70	57.5
80	58.0
88	58.3

Figure 2-2. Measured Input Terminal Q.

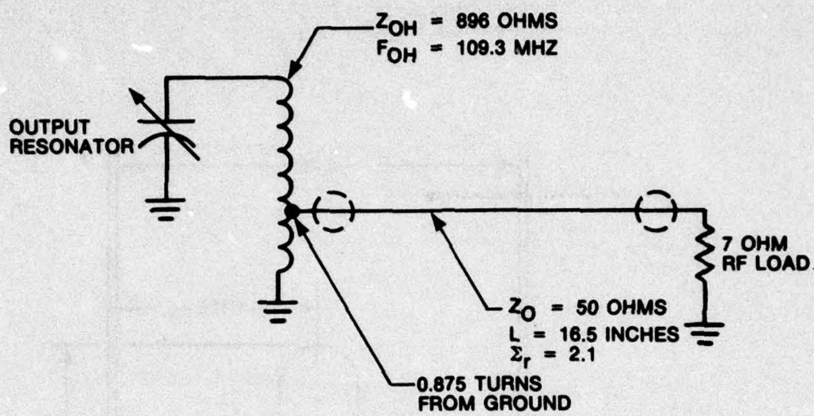
The output coupling approach, again identical to the Phase II design, is shown in figure 2-4. As expected, the interconnecting transmission line length was reduced a small amount to provide operation to 88 MHz. The line length, however, is sufficient to allow multicoupler configurations up to ten channels to be realized. Tap location is 1/4 turn closer to ground to achieve the desired coupling. Output terminal Q departs more from the desired value than for the other couplings. The shape and departure of the terminal Q curve from the ideal is the same as for the Phase II equipment.



DESIRED K = 0.0183 FROM 30 TO 88 MHZ

FREQUENCY MHZ	MEASURED K_1
30	0.0172
40	0.0175
50	0.0179
60	0.0185
70	0.0192
80	0.0199
88	0.0205

Figure 2-3. Measured Coupling Coefficient.



DESIRED Q_T = 59 FROM 30 TO 88 MHZ

FREQUENCY MHZ	MEASURED TERMINAL Q, Q_T
30	58.4
40	68.8
50	75.1
60	77.4
70	75.1
80	69.5
88	62.9

Figure 2-4. Measured Output Terminal Q.

Figures 2-5 and 2-6 show the steps in computing the element values for the 7- to 50-ohm broadband transformer of increased bandwidth (30 to 88 MHz). Figure 2-7 shows the final experimentally determined values. The measured return loss (50-ohm port with 7.2857-ohm load installed) is 23 dB or greater across the operating band. Thus, the transformer matches the 7-ohm load to 50 ohms within a maximum vswr of 1.15:1. This degree of match is slightly better than that obtained in the Phase II equipment.

2.2 Second-Quarter Report Period

2.2.1 Status

During this report period, effort continued on the basic design of the multicouplers to incorporate the desired changes. The changes included increasing the operating frequency range to 88 MHz, revising the capacitor drive assemblies to a single-speed drive with a separate knob lock, providing dial windows and front panel sealing, improving mounting and vibration performance, and providing fixed detent meter function switching.

FOLLOWING THE IDENTICAL PROCEDURE USED TO DESIGN THE PHASE II TRANSCEIVER MULTICOUPLER BROADBAND IMPEDANCE TRANSFORMER THE DESIGN IS EXTENDED TO 88 MHZ:

$$g_0 = 1.000,\ g_1 = 0.7128,\ g_2 = 1.2003,\ g_3 = 1.3212,\ g_4 = 0.6476,\ g_5 = 1.1007,\ \omega_1' = 1.000,\ L_{Ar} = 0.01\ \text{dB},\ n = 4$$

$$R_0 = \frac{51}{7} = 7.2857\Omega,\ N^4 R_5 = 50\Omega$$

$$N^4 R_5 = N^4 R_o g_5 = 50\Omega$$

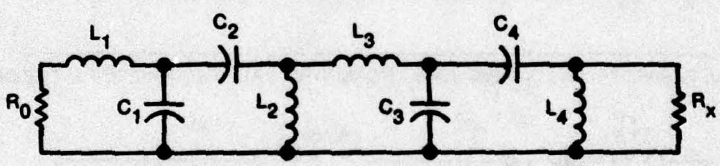
$$N = \left[\frac{50}{R_o g_5}\right]^{1/4} = \left[\frac{50}{(7.2857)(1.1007)}\right]^{1/4} = 1.5802$$

$$\omega = \sqrt{\frac{g_1 g_2}{N-1}} = \sqrt{\frac{(0.7128)(1.2003)}{0.5802}} = 1.2144$$

$$\omega = \frac{f_2 - f_1}{f_0} = \frac{f_0 - f_1}{\sqrt{f_1 f_2}},\ f_2 - 88 = 30 - f_1$$

$$f_1 = 59\ \left[1 - \frac{\omega}{\sqrt{4+\omega^2}}\right] = 28.3790\ \text{MHZ},\ f_2 = 118 - f_1 = 89.6210\ \text{MHZ}$$

$$f_0 = \sqrt{f_1 f_2} = 50.4317\ \text{MHZ},\ \omega_0 = 2\pi f_0 = 0.3169 \times 10^9\ \text{radians/second}$$



$$R_0 = 7.2857\ \Omega$$

$$L_1 = \frac{g_1 R_0}{\omega \omega_0} = \frac{(0.7128)(7.2857)}{(1.2144)(0.3169)} = 13.4962\ \text{nH}$$

$$C_1 = \frac{(N-1)\omega}{g_1 \omega_0 R_0 N} = \frac{(0.5802)(1.2144)(1000)}{(0.7128)(0.3169)(7.2857)(1.5802)} = 270.9453\ \text{pF}$$

Figure 2-5. Broadband Transformer Calculations (Part 1).

$$C_2 = \frac{\omega}{g_1 R_0 \omega_0 N} = \frac{(1.2144)\,(1.000)}{(0.7128)\,(7.2857)\,(0.3169)\,(1.5802)} = 467.005 \text{ pF}$$

$$L_2 = \frac{N^2 \omega R_0}{g_2 \omega_0} = \frac{(2.4970)\,(1.2144)\,(7.2857)}{(1.2003)\,(0.3169)} = 58.0846 \text{ nH}$$

$$L_3 = \frac{g_3 R_0 N^2}{\omega \omega_0} = \frac{(1.3212)\,(7.2857)\,(2.4970)}{(1.2144)\,(0.3169)} = 62.4634 \text{ nH}$$

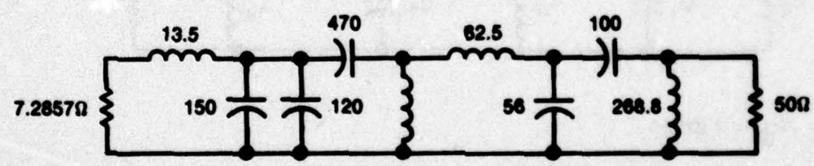
$$C_3 = \frac{(N-1)\,\omega}{g_3 \omega_0 R_0 N^3} = \frac{(0.5802)\,(1.2144)\,(1000)}{(1.3212)\,(0.3169)\,(7.2357)\,(3.9457)} = 58.5419 \text{ pF}$$

$$C_4 = \frac{\omega}{g_3 R_0 \omega_0 N^3} = \frac{(1.2144)\,(1000)}{(1.3212)\,(0.3169)\,(7.2857)\,(3.9457)} = 100.9026 \text{ pF}$$

$$L_4 = \frac{\omega R_0 N^4}{g_4 \omega_0} = \frac{(1.2144)\,(7.2857)\,(6.2349)}{(0.6476)\,(0.3169)} = 268.8178 \text{ nH}$$

$$R_x = g_5 N^4 R_0 = (1.1007)\,(6.2349)\,(7.2857) = 50 \text{ OHMS}$$

THE FINAL COMPUTED NETWORK USING STANDARD VALUE CAPACITORS, BECOMES:



INDUCTANCE IN nH CAPACITANCE IN pF

Figure 2-6. Broadband Transformer Calculations (Part 2).

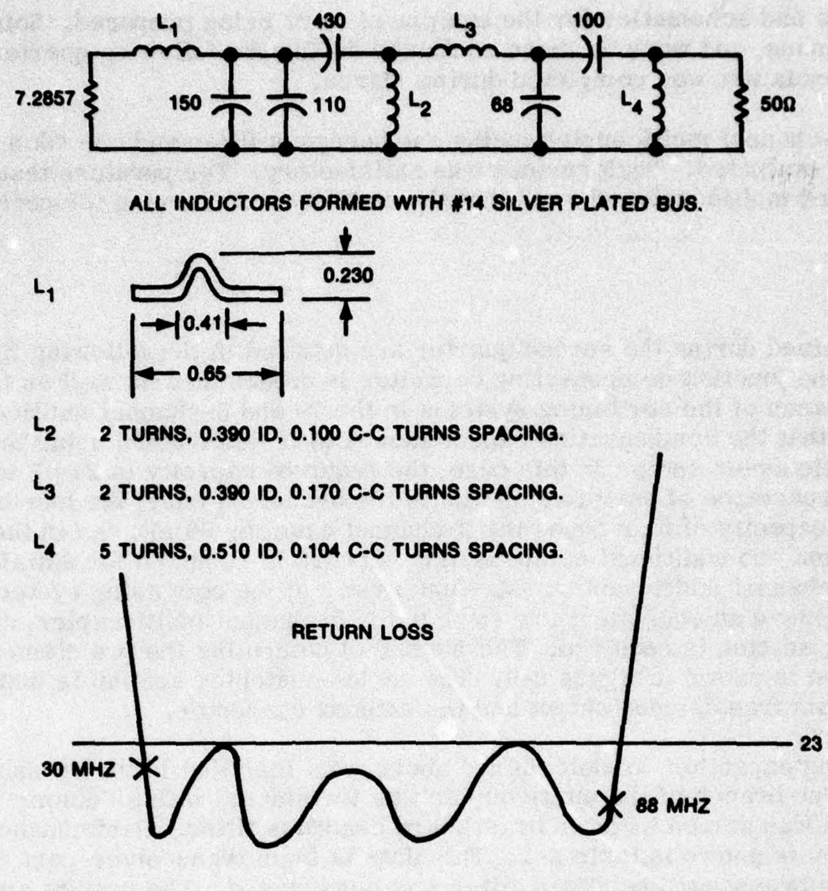


Figure 2-7. Broadband Transformer, Final Values and Measured Performance.

Evaluation of the brassboard filter was completed. Back impedance data taken on the brassboard filter allowed determination of the junction compensating capacitors for the 2- and 5-channel multicouplers. Design of the reactance cancellation network for the 5-channel multicoupler was also accomplished. The back impedance data also allowed the design of the "dummy" filter to be completed.

Satisfactory tracking of the 90-degree discriminator up to 88 MHz was verified, using the brassboard filter. Trial capacitor drive and knob lock assemblies were constructed and evaluated. Performance of these assemblies was satisfactory.

All electrical parts for the construction of the engineering models were received with the exception of the panel meter. This item was due the third-quarter report period. All fabrication drawings for the bandpass filter, "dummy" filter, and multicouplers were completed. All mechanical parts were fabricated for the engineering models with the exception of the bandpass filter chassis and the multicoupler mounting bases. These items were completed during the third-quarter report period.

Fabrication drawings for the 2- and 5-channel multicoupler transit cases were completed. These drawings were sent to the vendor for comments and quotes.

Outline drawings and schematics for the equipment were being prepared. Some assembly drawings were made, and work on these continued during the following quarter. Request for equipment nomenclature was completed during March.

A brassboard 2-channel multicoupler (using one bandpass filter and one "dummy" filter) was constructed and evaluated. Performance was satisfactory. Temperature tests performed on the brassboard multicoupler showed that the stability with varying temperature was excellent.

2.2.2 Results

The results obtained during the second quarter are detailed in the following figures. Figure 2-8 shows how the junction compensating capacitor is determined as well as the expected overall performance of the combining systems in the 2- and 5-channel multicouplers. It should be noted that the compensating capacitance (C_r) is determined using the 2-channel brassboard multicoupler setup. In this case, the required capacity is 24 pF to equalize the off-channel reactance of one branch; thus in the 5-channel case, the four branches require a compensating capacity of four times the 2-channel case, or 96 pF. As in the case of the Phase II equipment, no additional compensating network is required for satisfactory performance in the 2-channel multicoupler. Maximum vswr of the combining system is estimated at 1.16:1. To achieve an equivalent low vswr in the 5-channel multicoupler, an additional series-matching section is required. The method of computing the two elements for the additional section is shown in figure 2-9. The series-matching section is installed between the 7.2857/50-ohm transformer output and the antenna connector.

The compensating capacitor, as determined above, was installed in the brassboard 2-channel multicoupler. One branch of the multicoupler was terminated with a "dummy" filter, and the other branch was driven with the brassboard bandpass filter. Performance data taken on this configuration is shown in table 2-1. This data is from transceiver-port to antenna-port because only one brassboard bandpass filter was constructed. The results are in good agreement with the Phase II equipment performance data. In fact, the insertion loss data is now slightly better due to more iterations in the design of the bandpass filter's coupling structures to achieve a good match over the operating frequency range. Table 2-2 shows the variation in insertion loss and center frequency as the brassboard multicoupler was subjected to the specified operating temperature range. Insertion loss varied ±0.1 dB with temperature, being 0.1 dB higher at elevated temperature and 0.1 dB lower at low temperature as compared to the room temperature value. This variation is caused by a change in conductivity of the metals forming the helical resonator and tuning capacitor. Center frequency drift did not exceed 63 kHz. The temperature tests were performed at 30 MHz where worst-case frequency drift occurs. At higher operating frequencies, the helix stability determines the center frequency variation with temperature. Exhaustive testing on the Phase II equipment has shown that the helical resonator portion of the tuned tank circuit is more stable with temperature than the variable tuning capacitor.

Schematics showing all element values for the Phase III equipment are shown in figures 2-10 through 2-15.

MEASURED DATA: 2-CHANNEL MULTICOUPLER

THE VALUE OF THE COMPENSATING CAPACITOR (Cr) IS DETERMINED EXPERIMENTALLY. THE CORRECT VALUE IS THAT WHICH EQUALIZES THE MAGNITUDE OF THE OFF-CHANNEL REACTANCE AT THE BAND EDGES (30 AND 88 MHZ).

FOR: $C_r = 24$ pF, $X_{T_{30\ MHZ}} = X_{T_{88\ MHZ}} = 48$ OHMS

2-CHANNEL MULTICOUPLER:

THE 2-CHANNEL MULTICOUPLER REQUIRES NO ADDITIONAL MATCHING NETWORK. THE NETWORK CONSISTS OF THE COMPENSATING CAPACITOR AND THE 7.2857 - 50 OHM TRANSFORMER. THE PERFORMANCE CAN BE ESTIMATED AS:

$n = 1$, $r = 7.2857$ OHMS, $X_T = 48$ OHMS

$$\therefore \delta = \frac{|X_T|}{(1)r} = \frac{48}{7.2857} = 6.58825$$

$$H = \frac{\delta^2 + \delta\sqrt{\delta^2 + 1} + 1}{2\delta\sqrt{\delta^2 + 1}} = \frac{43.40501 + 43.90216 + 1}{87.80433} \approx 1.005727$$

MAX INSERTION LOSS RIPPLE ($L_{A_{max}}$) = $10 \log_{10} H = 0.0248$ dB

MAX VSWR = $2H - 1 + 2\sqrt{H(H-1)} = 1.163{:}1$

5-CHANNEL MULTICOUPLER:
THE 5-CHANNEL MULTICOUPLER REQUIRES AN ADDITIONAL SECTION FOR GOOD PERFORMANCE.

$$C_r = 4C_{r_{2\text{-channel}}} = 96 \text{ pF}$$

THE NETWORK CONSISTS OF THE COMPENSATING CAPACITOR, THE 7.2857-50 OHM TRANSFORMER, AND THE ADDITIONAL MATCHING SECTION. THE PERFORMANCE IS FOUND AS:

$n = 2$, $r = 7.2857$ OHMS, $X_T = 48$ OHMS

$$\therefore \delta = \frac{|X_T|}{(4)r} = \frac{48}{(4)(7.2857)} = 1.64706$$

$$H = \frac{(\delta^2 + \delta\sqrt{\delta^2 + 1} + 1)^2}{4\delta(\delta^2 + 1)^{3/2}} = \frac{(2.71281 + 3.17366 + 1)^2}{47.13276} = 1.006168$$

MAX INSERTION LOSS RIPPLE (LA_{max}) = $10 \log_{10} H = 0.0267$ dB

MAX VSWR = $2H - 1 + 2\sqrt{H(H-1)} = 1.170{:}1$

Figure 2-8. Calculated Matching Network Performance.

5-CHANNEL MULTICOUPLER

CALCULATION OF ELEMENT VALUES FOR ADDITIONAL MATCHING SECTION.

$n = 2$, $\delta = 1.64706$, $H = 1.006168$, $f_1 = 30$ MHZ, $f_2 = 88$ MHZ, $R = 50$ OHMS.

$$d = \left[\frac{\sqrt{\frac{1}{H-1}} + \sqrt{\frac{H}{H-1}}}{n}\right] = \sinh\left[\frac{(12.73291 + 12.77212)}{2}\right]$$

$$= \sinh 1.619438 = 2.42612$$

$$D = \frac{d}{\delta \sin \frac{\pi}{2n}} - 1 = \frac{2.42612}{1.64706 \sin \frac{\pi}{4}} - 1 = 1.08314$$

LETTING: $g_0 = 1$, $\omega_1^1 = 1$

$$g_1 = \frac{1}{\delta} = \frac{1}{1.64706} = 0.607142$$

$$f_0 = \sqrt{f_1 f_2} = \sqrt{(30)(88)} = 51.38093 \text{ MHZ} \quad \omega_0 = 0.322836 \times 10^9 \text{ RAD/SEC}$$

$$\omega = \frac{f_2 f_1}{f_0} = \frac{58}{51.38093} = 1.128823$$

$$k_{12} = \sqrt{\frac{1 + (1 + D^2)^2}{2}} = \sqrt{\frac{1 + (2.17319)(2.71281)}{2}} = 1.85680$$

$$g_2 = \frac{1}{g_1 (k_{12})^2} = 0.47772, \quad g_3 = \frac{1}{D\delta g_2} = 1.17335$$

$$X_L = X_C = \frac{\omega_1^1 g_2 R}{\omega} = \frac{(0.47772)(50)}{1.128823} = 21.16008 \text{ OHMS}$$

$$L = \frac{X_L}{\omega_0} = \frac{21.16008}{0.322836} = 65.544 \text{ nH}$$

$$C = \frac{1}{X_c \omega_0} = \frac{1000}{(21.16008)(0.322836)} = 146.386 \text{ pF}$$

Figure 2-9. Matching Section Element Determination.

Table 2-1. Test Data, Brassboard 2-Channel Multicoupler (27 March 78).

FREQUENCY (MHz)	INSERTION LOSS (dB)	f + 3 dB (MHz)	f - 3 dB (MHz)	f_o + 5% (dB)	f_o - 5% (dB)	3-dB BW (MHz)	*RETURN LOSS* (dB)	*VSWR*
30	1.3	30.417	29.572	39.0	42.7	0.845	30.0	1.065:1
35	1.3	35.505	34.521	38.8	41.5	0.984	22.0	1.173:1
40	1.3	40.562	39.424	39.2	41.6	1.138	18.0	1.288:1
45	1.2	45.651	44.361	39.0	41.9	1.290	20.0	1.222:1
50	1.1	50.738	49.292	38.5	41.8	1.446	24.0	1.135:1
55	1.1	55.783	54.167	38.8	40.8	1.616	24.0	1.135:1
60	1.1	60.920	59.135	38.8	41.0	1.785	21.0	1.196:1
65	1.3	65.970	64.022	39.6	41.1	1.948	18.0	1.228:1
70	1.3	71.047	68.928	39.3	41.4	2.119	17.0	1.329:1
75	1.2	76.155	73.853	38.1	41.2	2.302	18.0	1.288:1
80	1.1	81.222	78.739	37.6	40.2	2.483	22.0	1.173:1
85	1.0	86.271	83.631	37.8	39.3	2.640	36.0	1.032:1
88	1.0	89.370	86.603	38.1	39.3	2.767	33.0	1.046:1

Table 2-2. Brassboard Multicoupler Temperature Test Data (27 March 78).

TEST CONDITION	INSERTION LOSS (dB)	f_1, LOWER 3-dB FREQUENCY (MHz)	f_2, UPPER 3-dB FREQUENCY (MHz)	*f_o (MHz)
Start, +24 °C	1.3	29.578	30.424	30.001
Stabilized, -46 °C	1.2	29.639	30.488	30.064
Stabilized, +71 °C	1.4	29.556	30.416	29.986
Finish, +24 °C	1.3	29.602	30.445	30.024

$$*f_o = \frac{f_1 + f_2}{2}$$

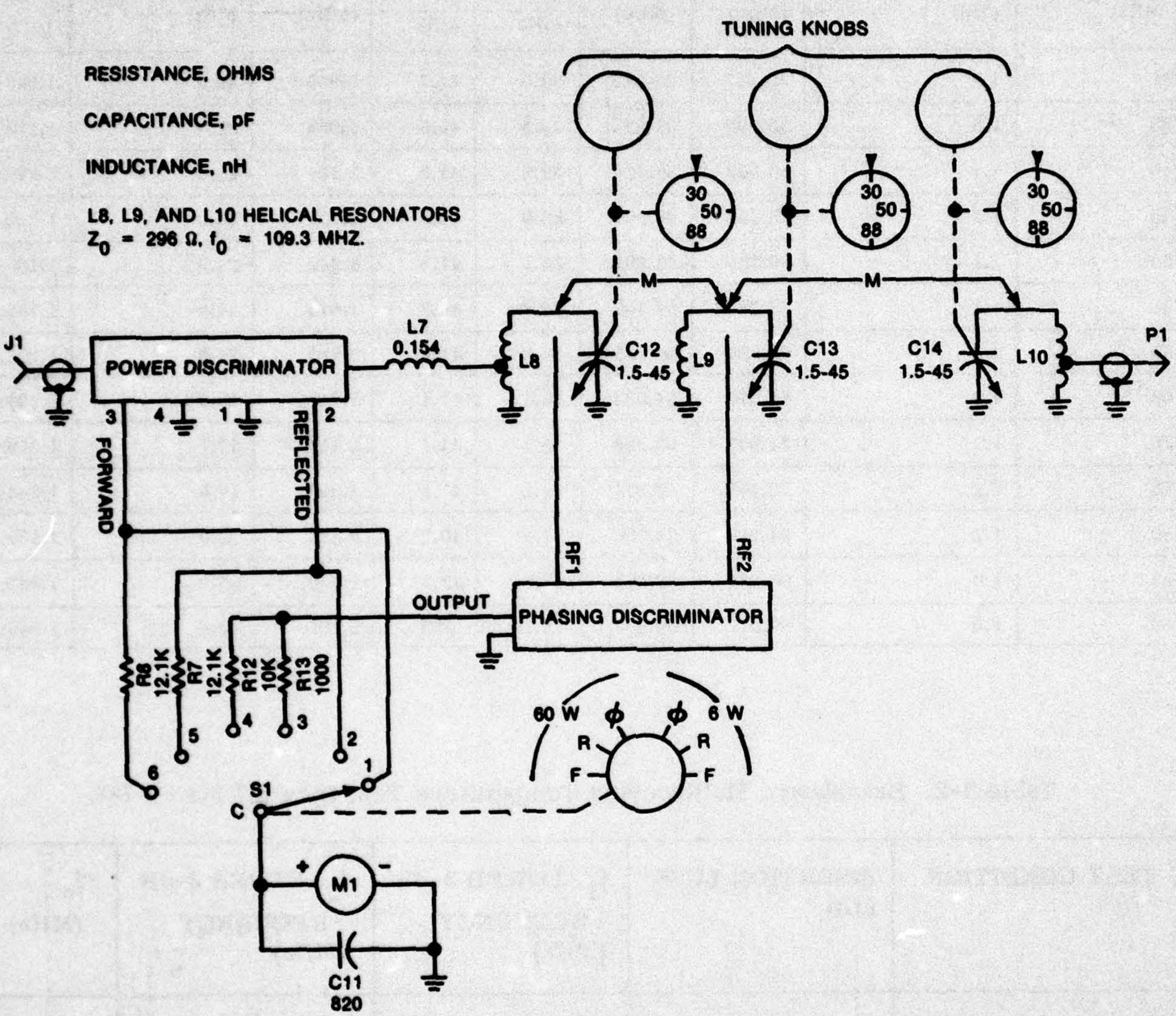


Figure 2-10. Schematic, Bandpass Filter.

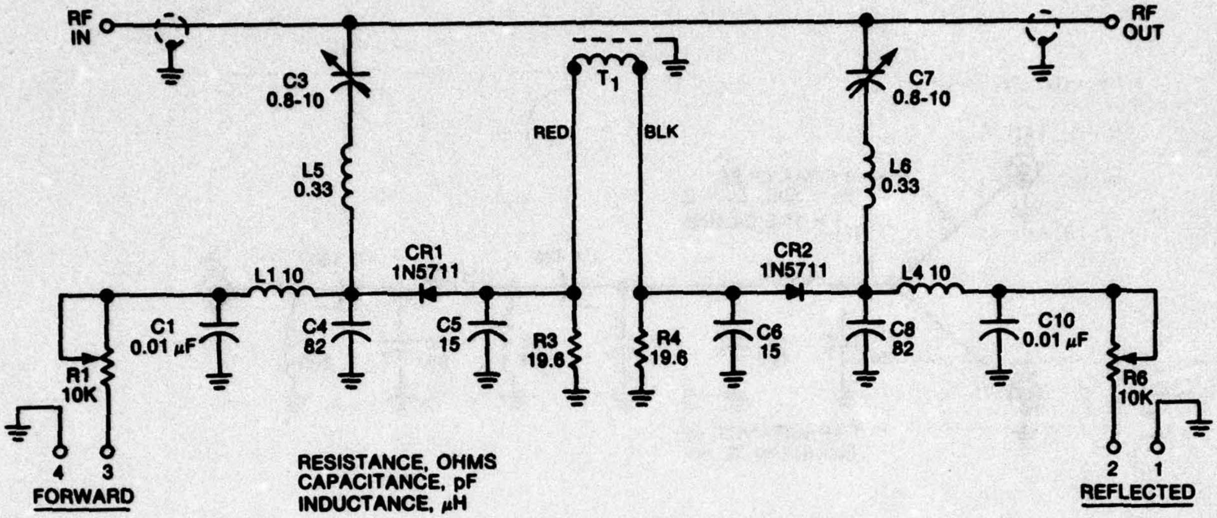


Figure 2-11. Schematic, Power Discriminator.

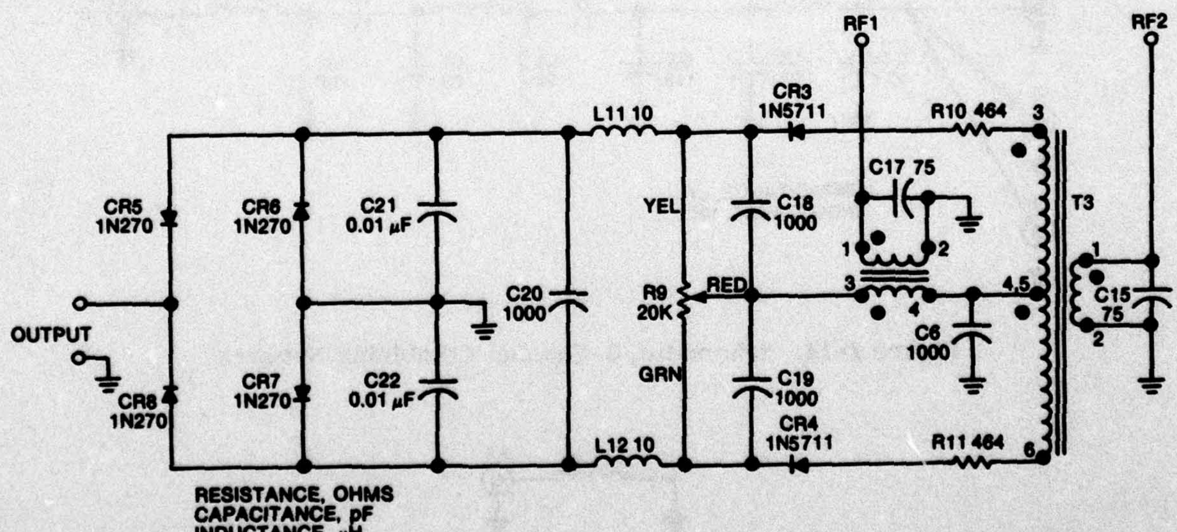


Figure 2-12. Schematic, Phasing Discriminator.

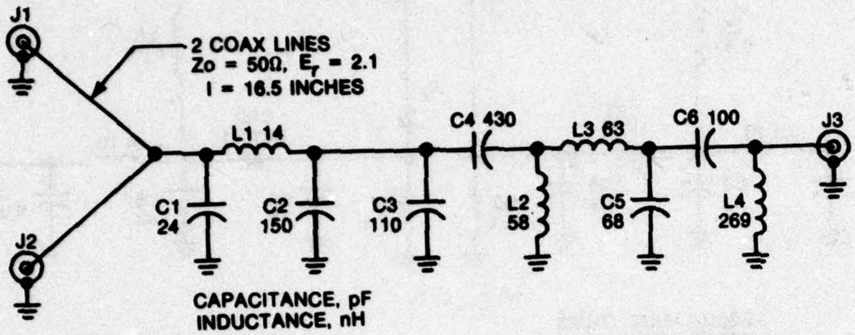


Figure 2-13. Schematic, 2-Channel Combining Network.

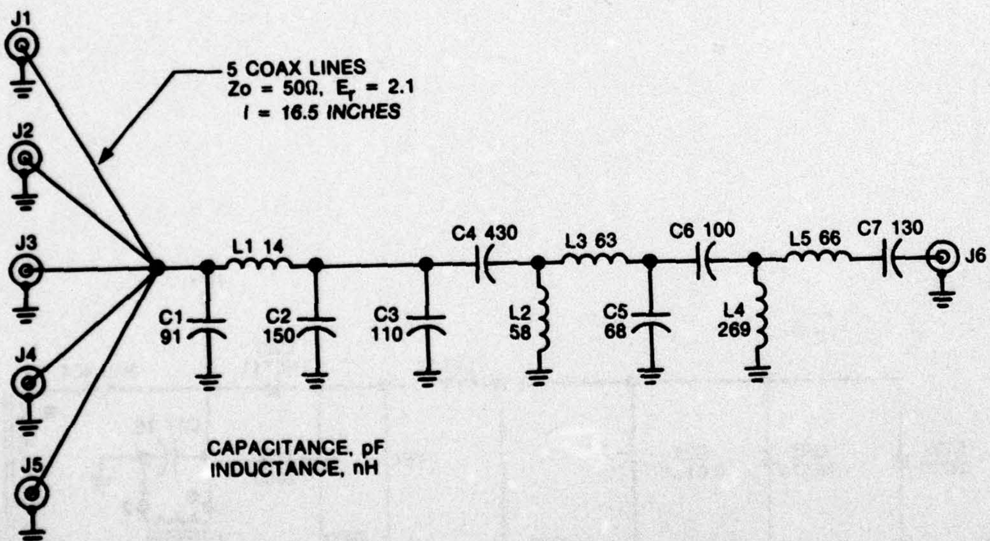


Figure 2-14. Schematic, 5-Channel Combining Network.

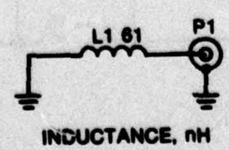


Figure 2-15. Schematic, Filter Simulator.

2.3 Third-Quarter Report Period

2.3.1 Status

During this report period, effort continued on the basic design of the multicouplers to incorporate the desired changes. The changes included increasing the operating frequency range to 88 MHz, revising the capacitor drive assemblies to a single-speed drive with a separate knob lock, providing dial windows and front panel sealing, improving mounting and vibration performance, and providing fixed detent meter function switching.

Construction and bench testing of the engineering evaluation equipment was completed. This equipment included three bandpass filters, three filter simulators, one 2-channel mounting base, one 5-channel mounting base, and transit cases for both the 2- and 5-channel multicouplers.

All fabrication drawings and purchased parts lists were completed and released to the Manufacturing Department. Procurement of parts for the construction of the deliverable equipment began.

2.3.2 Results

The results obtained during the third quarter are detailed in the following tables. Tables 2-3 through 2-5 show the performance data for the three bandpass filters. Data for each filter is taken in the 2-channel multicoupler base with the unused multicoupler port terminated in a filter simulator. The data is from transceiver-port to antenna-port in this case. Performance of the engineering models is in good agreement with the brassboard model described in the last quarterly report. Insertion loss is lower than the Phase II equipment due to more iterations in the design of the coupling structures of the bandpass filter, achieving a good match over the operating frequency range.

Table 2-6 shows some transceiver-port-to-transceiver-port attenuation data. Again, these tests were performed in the 2-channel base with all possible combinations of the three bandpass filters, as shown. The attenuation is approximately 46 dB. This is 6 dB better than the specified limit but is about 5 dB less than that obtained with the Phase II equipment. The reason for this decreased isolation is the fact that the interconnect lines in the mounting base are shorter on the Phase III equipment. The shorter lines are necessary to extend the operating frequency range upper limit from 80 to 88 MHz.

The bandpass filters of both designs give the same attenuation, but the added attenuation contributed by the combining system is less for the Phase III equipment because of the increased operating frequency range.

Also during this report period, some investigations have been conducted with the aim of improving the operation of the 5-channel multicoupler or any higher-channel multicoupler requiring additional Fano matching. In the prior equipment, each communications channel of the 5-channel multicoupler had slightly poorer performance than a communications channel in a 2-channel multicoupler. This occurred despite the theory which predicted that a 5-channel multicoupler's performance (with one stage of Fano matching) should be nearly the same as a 2-channel multicoupler (with no Fano matching).

The reason for this performance difference has been traced to the method of implementing the Fano matching circuitry. Figure 2-16 (a) shows the prior method where the series compensating network was implemented at the 50-ohm side of the lumped transformer. This location was chosen because it reduced component size. It has been found, however, that the

Table 2-3. Test Data, Engineering Filter #1 (25 July 78).

FREQUENCY (MHz)	INSERTION LOSS (dB)	f - 3 dB (MHz)	f + 3 dB (MHz)	f_o - 5% (dB)	f_o + 5% (dB)	3-dB BW (MHz)	RETURN LOSS (dB)	VSWR
30	1.45	29.566	30.313	40.8	38.5	0.827	22.5	1.162
40	1.30	39.428	40.536	40.1	39.6	1.108	30.0	1.065
50	1.10	49.287	50.692	40.5	39.2	1.405	29.0	1.074
60	1.10	59.087	60.813	39.6	39.4	1.726	30.0	1.065
70	1.25	68.934	71.001	39.7	39.0	2.067	28.0	1.083
80	1.20	78.735	81.154	39.3	38.8	2.419	27.0	1.094
88	1.20	86.625	89.339	39.2	38.9	2.714	21.5	1.184

Table 2-4. Test Data, Engineering Filter #2 (25 July 78).

FREQUENCY (MHz)	INSERTION LOSS (dB)	f - 3 dB (MHz)	f + 3 dB (MHz)	f_o - 5% (dB)	f_o + 5% (dB)	3-dB BW (MHz)	RETURN LOSS (dB)	VSWR
30	1.40	29.573	30.414	40.9	37.8	0.841	29.0	1.074
40	1.30	39.433	40.565	40.0	38.8	1.132	24.0	1.135
50	1.10	49.263	50.691	40.1	38.8	1.428	27.0	1.094
60	1.10	59.076	60.833	39.3	38.8	1.757	25.0	1.119
70	1.25	68.903	71.016	39.0	38.3	2.113	21.0	1.196
80	1.20	78.730	81.193	38.9	38.0	2.463	27.0	1.094
88	1.10	86.586	89.349	39.6	38.6	2.763	31.0	1.058

Table 2-5. Test Data, Engineering Filter #3 (27 July 78).

FREQUENCY (MHz)	INSERTION LOSS (dB)	f - 3 dB (MHz)	f + 3 dB (MHz)	f_o - 5% (dB)	f_o + 5% (dB)	3-dB BW (MHz)	RETURN LOSS (dB)	VSWR
30	1.40	29.586	30.413	41.1	37.7	0.827	24.0	1.135
40	1.30	39.445	40.556	40.3	38.9	1.111	23.0	1.152
50	1.20	49.255	50.658	40.2	39.2	1.403	28.0	1.083
60	1.20	59.105	60.825	39.9	39.0	1.720	27.5	1.088
70	1.30	68.940	71.002	39.7	38.7	2.062	24.0	1.135
80	1.30	78.782	81.190	39.7	38.4	2.408	31.0	1.058
88	1.20	86.623	89.317	39.3	38.8	2.694	25.0	1.119

Table 2-6. Test Data, Transceiver-Port-To-Transceiver-Port Attenuation (27 July 78).

ENGINEERING FILTER NUMBER	RESONANT FREQUENCY (MHz)	ATTENUATION (dB)
1 2	30.0 31.5	47.4
1 2	60.0 63.0	46.2
1 2	80.0 84.0	45.7
1 2	30.0 31.5	47.1
1 3	60.0 63.0	46.8
1 3	80.0 84.0	46.7
2 3	30.0 31.5	47.1
2 3	60.0 63.0	46.9
2 3	80.0 84.0	46.2

reactive mismatch component introduced at the 7-ohm point in the circuit is not properly transformed by the lumped transformer in a manner suitable for cancellation by the series network. Implementing the series network at the 7-ohm point (figure 2-16 (b)) cancels the reactive mismatch prior to the impedance transformation. This results in improved performance comparable to that obtained in the 2-channel multicoupler. The new implementation requires two capacitors in parallel because of the higher current at the 7-ohm interface. The new design has been incorporated into the present 5-channel multicoupler.

Effort has continued during this report period on improving and finalizing the knob lock design. Operation has been improved by slightly modifying the shape of the locking cam surface. Failure to lock due to material stretching has been eliminated by employing high-tensile-strength steel in the tuning shaft clamp piece. Difficult accessibility (tuning knob closest to the mounting surface) has been improved by redesigning the lever location and style as shown in figure 2-17.

Results of the transit case evaluations required a minor revision to the foam inserts in the 5-channel case. The 2-channel transit case was satisfactory as received from the vendor.

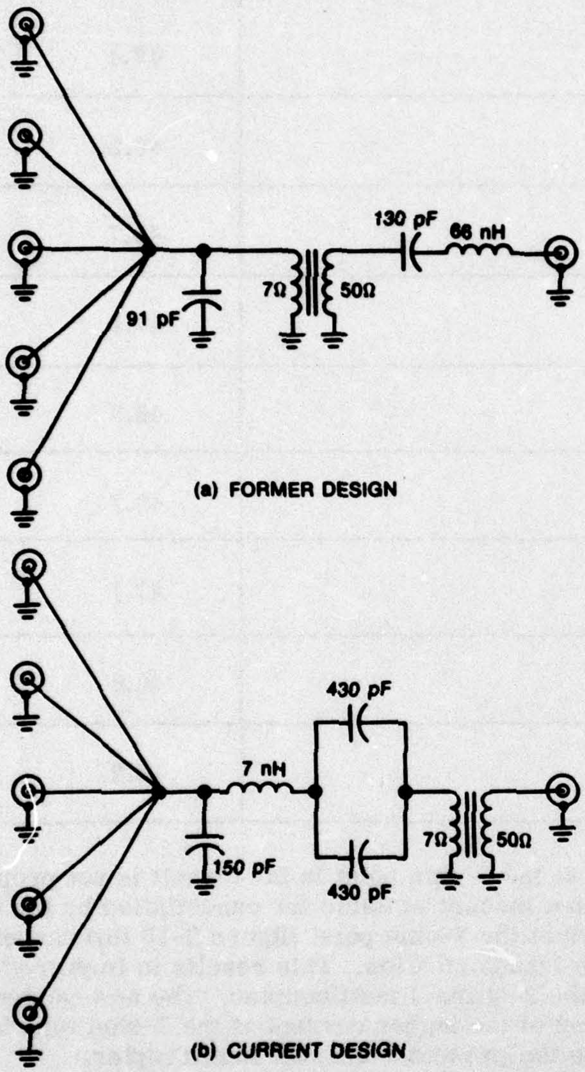


Figure 2-16. Matching Network Configurations (5-Channel).

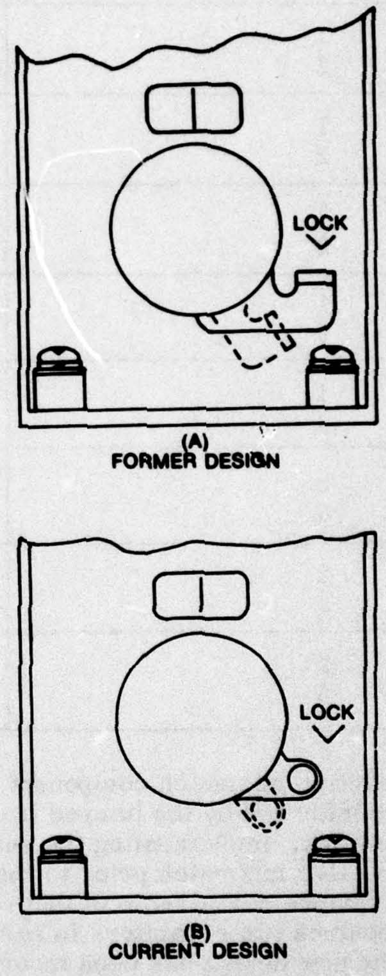


Figure 2-17. Knob Lock Configuration.

2.4 Fourth-Quarter Report Period

2.4.1 Status

During this report period, effort was completed on the incorporation of the desired design changes. Engineering cognizance was transferred from the HF Products Department to the LOS Products Department.

The Design Phase of the program was completed. All drawings and schematics were completed and released to Manufacturing.

Engineering cognizance was transferred to the Filter/Multicoupler Group of the LOS Products Department. This equipment transfer will allow a greater concentration of company resources toward the continuing success of the multicoupler program.

2.4.2 Results

There were no technical results to report this period.

2.4.3 Plan

All of the items scheduled for completion last quarter have been accomplished with the exception of the limited environmental testing. This item will be completed during the following quarter.

October: Continue procurement of parts for deliverable equipment.

November: Complete limited environmental testing on engineering equipment (temperature and vibration).

December: Provide engineering assistance to Manufacturing and other support areas.

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